

In the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

1. (Previously Presented) A method of detecting surface particulate defects, and especially metal particulates, in semiconductors such as silicon, to characterise defects likely to have an effect on the electrical activity of such semiconductor materials, comprises the steps of:

annealing a semiconductor structure to diffuse contaminants from a surface particulate into the semiconductor material;

after annealing the semiconductor structure, exposing the surface of the semiconductor structure in the vicinity of a surface particulate to at least one high-intensity beam of light from a suitable light source;

collecting photoluminescence produced by excitation of the semiconductor structure by the light beam;

processing the collected photoluminescence to produce a result representative of the intensity of the photoluminescence response;

comparing the result with a predetermined acceptable specification range of photoluminescence to identify unacceptable contamination levels resulting from diffusion of contaminants from the surface particulate into the semiconductor structure.

2. (Original) A method in accordance with claim 1 as a method of quality control comprising a further step of making a quality classification of the semiconductor structure based upon such a comparison, and rejecting or selecting for remedial action semiconductor structures exhibiting a photoluminescence response outside the said predetermined acceptable specification range.

3. (Previously Presented) A method in accordance with claim 2 further comprising a prior step of determining a predetermined acceptable specification from studies of samples of fabricated devices using electrical yield test methods.

4. (Cancelled)

5. (Previously Presented) A method in accordance with claim 1 wherein the exposing, collecting and processing steps are performed prior to and subsequent to the annealing step and the results compared to determine the difference and obtain an indication of rates of diffusion so as to identify the contaminant.
6. (Original) A method of detecting surface particulate defects, and especially metal particulates, in semiconductors such as silicon, to characterise defects likely to have an effect on the electrical activity of such semiconductor materials, comprises:
 - a first step of collecting photoluminescence by:
 - exposing the surface of the semiconductor structure in the vicinity of a surface particulate to at least one high-intensity beam of light from a suitable light source;
 - collecting photoluminescence produced by excitation of the semiconductor structure by the light beam;
 - processing the collected photoluminescence to produce a first photoluminescence result representative of the intensity of the photoluminescence response;
 - a heating step to the semiconductor to diffuse contaminant from the particle into the semiconductor material;
 - a second step of collecting photoluminescence produced by like method to the first to produce a second photoluminescence result representative of the intensity of the photoluminescence response as above described after annealing;
 - a step of comparing the results of each photoluminescence step to determine the difference and obtain an indication of rates of diffusion so as to identify the contaminant.
7. (Previously Presented) A method in accordance with claim 6 wherein the light source is a high-intensity laser.
8. (Original) A method in accordance with claim 7 wherein the spatial resolution of the laser is 0.1 to 20 μm .
9. (Previously Presented) A method in accordance with claim 7 wherein the laser provides a peak or average power density of between 10^4 to 10^9 watts/cm².

10. (Previously Presented) A method in accordance with claim 6 wherein the light beam used to generate the PL effect is so controlled as to collect PL information from no deeper than the upper 12 μ m of the semiconductor structure.
11. (Previously Presented) A method in accordance with claim 6 comprising a first step of locating surface particulates using a suitable particulate imaging method, and a subsequent or simultaneous second step of generating PL intensity information in accordance with any preceding claim from the vicinity of each particulate to provide a quantification of the extent to which contaminant has diffused from the particulate into the near-surface region of the semiconductor.
12. (Original) A method in accordance with claim 11 wherein the particulate imaging, mapping and locating method comprises the generation of a scattered light dark field image and/or a reflected light bright field image.
13. (Original) A method in accordance with claim 12 including the steps of:
 - directing a high intensity beam of light such as a high-intensity laser at a surface of a sample of semiconductor structure to be tested in the manner above described;
 - producing a first or photoluminescence image from photoluminescence produced by excitation of the semiconductor structure by the light beam;
 - producing a second image mapping the location of the particulates, either as a dark field image of light scattered from the surface of the semiconductor structure or as a bright field image of light reflected from the surface of the semiconductor structure;
 - using the second image to detect and map surface particulates;
 - processing the photoluminescence image to produce a result representative of the intensity of the photoluminescence response of the semiconductor structure in the vicinity of the surface particulates so detected.
14. (Previously Presented) An apparatus for detecting surface particulate defects, and especially metal particulates, in semiconductors such as silicon, to characterise defects likely

to have an effect on the electrical activity of such semiconductor materials, comprises a support for a semiconductor sample under test; means to heat the sample under test associated with the support to diffuse contamination from a particulate into a semiconductor structure of the sample under test; a high intensity light source; means to focus a high intensity beam of light from the light source onto a surface of a semiconductor sample under test on the support; collection means to collect photoluminescence data produced by excitation of the semiconductor structure by the light beam at least in the vicinity of particulates on the surface thereof; means to process the collected data to produce a result representative of the intensity of the photoluminescence response in the said vicinity; a comparator to compare the result with a predetermined acceptable specification range of photoluminescence to identify unacceptable contamination levels resulting from diffusion of contaminant from particulate into semiconductor structure.

15. (Previously Presented) An apparatus in accordance with claim 14 wherein the means to heat the sample under test associated with the support comprises a heated stage.
16. (Original) An apparatus for detecting surface particulate defects, and especially metal particulates, in semiconductors such as silicon, to characterise defects likely to have an effect on the electrical activity of such semiconductor materials, comprises a support for a semiconductor sample under test; a high intensity light source; means to focus a high intensity beam of light from the light source onto a surface of a semiconductor sample under test on the support; collection means to collect photoluminescence data produced by excitation of the semiconductor structure by the light beam at least in the vicinity of particulates on the surface thereof; means to process the collected data to produce a result representative of the intensity of the photoluminescence response in the said vicinity; heating means to heat the sample in situ, allowing a photoluminescence response to be measured before and after heating, and a comparator to compare the said two photoluminescence responses to determine the difference and obtain an indication of rates of diffusion so as to identify the contaminant.
17. (Previously Presented) An apparatus in accordance with claim 16 wherein the heating means comprises a heated stage.

18. (Previously Presented) An apparatus in accordance with claim 17 further including imaging means to create an image map of the location of particulates on the surface of the semiconductor structure.

19. (Original) An apparatus in accordance with claim 18 wherein the imaging means generates a scattered light dark field image and/or a reflected light bright field image.

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